Transportation Planning Casebook/Hyperloop

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OVERVIEW

In the 2008 general election, the majority (52%) of California voters chose 'YES' on what was known as Proposition 1A, giving the green light go ahead for the state to issue a $9.95 billion bond measure that would help fund an 800-mile High-Speed Train network said to ultimately connect Los Angeles and San Francisco,

with intermediary stops along the way, providing a "safe, convenient, affordable and reliable alternative to driving and high gas prices."[1]. What the people of California did not know was that the projected cost estimates would nearly double over the next 4 years and that the seemingly "dig ready" project was in fact far from it, as the construction would end up being delayed by over a year.

Amidst the turmoil and uncertainty over the High-Speed Rail (HSR) project, billionaire entrepreneur-slash-businessman-physicist Elon Musk decided to stir the pot by proposing an alternative solution for statewide mass transit that he claimed would be cheaper to build, cheaper to operate, safer, faster, sustainably self-powering, immune to weather, resistant to earthquakes and not disruptive to those along the route[2]. His solution is for Hyperloop, a system of low pressure, elevated tubes in which capsules or pods (used interchangeably) carrying travelers would cruise through at speeds greater than 800 mph, or in the words of Musk, a transit system that is “a cross between a Concorde, a rail gun, and an air hockey table.” Although it is still uncertain whether or not Hyperloop is technically feasible, Musk's proposal itself brings up some very important points about the technological state of our nations transportation system. Should we really be spending billions of dollars on what he considers outdated and inconvenient technology? Are we going to do anything to change it?

TIMELINE

1993, July - SCR 6, Kopp. Transportation: intercity high-speed rail filed with Secretary of State (Establishes California Intercity High-Speed Rail Commission)

1996, September - SB 1420, Kopp. Transportation: High-Speed Rail Act filed with Secretary of State (Established a nine-member High-Speed Rail Authority in California)

2008, November - Proposition 1A is passed during the general election by California Voters

2009, October - Governor Arnold Schwarzenegger reveals California's application for $4.7 billion in American Recovery and Reinvestment Act (ARRA) funding

2010, January - White House announces that California will receive $2.35 billion of its request, of which $2.25 billion is specifically for HSR

2010, October - Federal government awards the Authority $900 million more fore rail improvements, of which $715 million is specifically for HSR

2010, December - Department of Transportation (DOT) reallocates $624 million out of the $1.2 billion in rejected ARRA funding from other states

2011, May - DOT awards $300 million to Authority after Florida rejects $2 billion in federal high-speed rail funding

2013, August - Elon Musk releases 58-page Hyperloop proposal on Tesla Motors blog

2013, October - Hyperloop Transportation Technologies Inc is started through Jumpstartfund.com

LIST OF MAJOR PLAYERS

United States Federal Government - Funding

U.S. Taxpayers

Government of the State of California

Edmund Gerald "Jerry" Brown, Jr., current Governor of California

California High Speed Rail Authority (CHSRA), the Authority

California Citizens

Elon Musk

Hyperloop Transportation Technologies Inc.

JumpstartFund.com

Amtrak

Caltrain

CALIFORNIA HIGH-SPEED RAIL

High speed rail is defined differently by governmental bodies. Different components, such as infrastructure, rolling stock (any vehicle that uses a railway) and their level of integration are all important parts that must meet certain standards in order for a rail system to be defined as high speed. The U.S. Federal Railroad Administration (FRA) has four definitions of passenger rail. The fastest, HSR - Express, operates at top speeds of at least 150 mph, has frequent service between major population centers located 200 - 600 miles apart, and has dedicated, grade-separated track[3]. This is the context of 'high speed rail' in this Wikibook.

BACKGROUND

The Intercity High-Speed Rail Commission (IHSRC) was created in July of 1993. The body was charged with creating a 20-year high-speed intercity ground transportation plan, with construction beginning in 2000. A rail line from San Francisco to Los Angeles was to be its first priority. A second bill was introduced in 1996, again co-authored by state senator Quentin Kopp, creating the California High Speed Rail Authority. The Authority naturally built upon the feasibility studies conducted by the IHSRC. The Authority employs around 70 people: it has a nine-member policy board, a core staff, and a chairman. Kopp was the first chairman, appointed in 1998, though he no longer chairs the Authority.

The Authority released its first business plan in 2000, and a draft environmental report in 2004 describing HSR's statewide effects. Proposition 1A went before California voters in the 2008 general election, and passed with 52.7% of the vote. The approval of Proposition 1A only allowed the State to sell $9.95 billion in bonds, to be used on pre-construction and construction activities, and "capital improvements to passenger rail systems that expand capacity, improve safety, or enable train rider to connect to the high-speed train system[4]."

In order to gain CA citizens' vote, a number of figures were put forth in the official voter guide. Key facts were: 1) The train is to be electrically-powered. 2) The system would connect San Francisco, Sacramento, the Central Valley, Los Angeles, greater Orange County, the Inland Empire (San Bernardino and Riverside Counties), and

San Diego. 3) The cost to develop the entire system would be $45 billion, with funding coming from a combination of federal, private, local, and state monies.

HISTORIC HIGH-SPEED RAIL BACKGROUND

As noted above, there are different definitions of high speed rail. The United States officially defines high speed rail, under the Federal Rail Administration, as any rolling stock that reaches operating speeds greater than 150 mph, among other conditions. The European Union has somewhat similar standards, such as a minimum top operating speed of 155 mph (250 km/h)[5]. While high speed rail service may seem novel to many Americans, high speeds achieved by rail are nothing new. Rather, it is the relatively sparse implementation of regular HSR systems in America, compared to other first world nations that engenders such novelty.

In 1903, in Germany, experimental railcars built by Siemens and AEG reached a speed of 207 km/h (128 mph)[6]. In 1933, a German company introduced a diesel-powered train (the Flying Hamburger) that regularly reached 99 mph between its service of Hamburg and Berlin, which, at the time, established the fastest regular service in the world[7].

American rail services were also quite advanced in terms of miles and passenger service. In 1936, the Twin Cities Zephyr line entered service. In 1940, it reached a maximum average speed of 71 mph (6 hours) between St. Paul and Chicago[8], whereas today, the route, now operated by Amtrak, takes 8 hours and 15 minutes (52 mph avg.) to complete the same trip[9].

Rail speed records were frequently set in the late 1930s. Notable among them was the Mallard steam locomotive in Great Britain, which reached 126 mph in 1938. However, internal combustion engines would soon outpace the iconic steam engines; their external combustion engines and boilers were large, heavy, and more difficult to maintain.

File:TwinZephyrs.png
Brochure cover for CB&Q Railroad Co.'s new streamlined Zephyr passenger trains, 1937

Many more high speed records were broken, but in October 1964, the Japanese Shinkansen (new trunk line) was the first modern high speed rail system to be opened. The system ran between Tokyo and Osaka, which had a population of 45 million at the time. The first trains ran 320 miles in 3 hours and 10 minutes, could reach 130 mph in operation, and had an average speed of 101 mph, with two stops. In France, the success of the Shinkansen rail spurred the upgrade of existing rail systems. In 1967, the first regular high speed service by a classic train began, at 124 mph (200 km/h), running between Toulouse and France. The improvements made to create faster service mainly entailed the signals system and curve revision.

The French broke (or shattered) the next notable barrier, 250 km/h, with the electric-powered TGV (Turbotrain Grande Vitesse). 236 mph (380 km/h) was achieved in 1981. The TGV repeatedly broke a few of its own records, recently reaching 357 mph (575 km/h) in 2007[10] However, in 2003 the Japanese broke the manned speed record in the unconventional rail category with their experimental Superconducting Maglev, which reached a speed of 361 mph[11]. Currently, the fastest train service in the U.S. is the Acela Express, which operates between Washington D.C. and Boston, reaching a maximum average speed of 70 mph. The Acela just classifies as a high speed rail, as it occasionally reaches 150 mph in regular service.

OVERVIEW

In 2009, the American Recovery and Reinvestment Act was passed, which earmarked $8 billion for HSR. A year later, the Obama Administration announced a six-year, $53 billion plan for HSR. California is expected to be the largest recipient of those funds. Since the approval of Proposition 1A, the total cost of the HSR project has substantially fluctuated from the initial $45 billion. In 2011, the cost rose to $98.5 billion, and was later revised down to $68.4 billion, the current figure. In July 2012, Jerry Brown, the Governor, signed a law approving construction financing for the initial segment between Merced and the San Fernando Valley. The first $5.8 billion of the approved $9.95 billion in bonds were issued by the State, which freed up an additional $3.2 billion from the federal government, which must be used by 2017[12]. Thus far, about one fifth of the total funding needed for the project has been issued.

The cost of issued bonds depends on the current interest rate and repayment period. Under Proposition 1A, the bonds can have a repayment period of 40 years, though the state's current practice is to issue the bonds with 30 year repayment periods. If the bonds are sold at a 5% interest rate, with a repayment period of 30 years, the principal would be about $9.5 billion, for a total of $19.4 billion when the original $9.95 billion is added. Thus, the average repayment for principal and interest would be about $647 million per year[13].

$10 of the required $68 billion is covered by Proposition 1A, leaving $58 billion to be secured through federal and private funding. The Authority believes it should be able to attain $12 to $16 billion through existing and new federal programs for high speed rail. These federal funds would help the Authority leverage to private investors, as the additional funds would give the project legitimacy, that it is going to happen. The Authority is targeting $2 to $3 billion in local support through cost sharing with local agencies, revenues from transit-oriented development, commercial concessions at stations, and cooperative funding arrangements with local transportation agencies. Lastly, based on the powers granted to it in its enabling legislation and assuming more normalized market conditions, the Authority plans to execute innovative public-private partnerships ("P3s") and is targeting $6.5 to $7.5 billion in P3 demand[14].

PROPOSED ROUTE

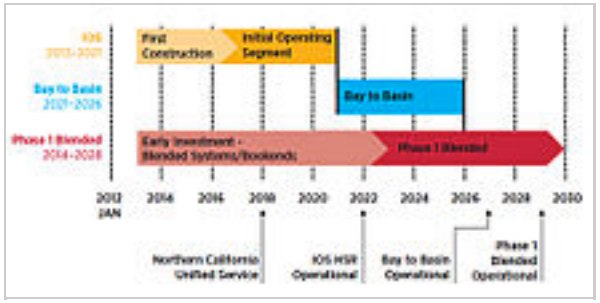
According to the California High-Speed Rail Authorities Revised 2012 Business Plan[15], the final system will run from San Francisco down to San Diego and will have an alternative route to Sacramento that joins the main line in between Merced and Fresno. The proposed route from the Revised 2012 Business Plan can be seen at the right.

PROPOSED CONSTRUCTION PHASES

The construction of the total system is proposed to be done in phases; Step 1 - Early Investments, Statewide Benefits; Step 2 - Initial High-Speed Rail Operations; Step 3 - The Bay to Basin System; Step 4 - The Phase 1 System; and Step 5 - The Phase 2 System.

STEP 1 - Early Investments

According to the Revised 2012 Business Plan, step 1 was supposed to begin sometime in 2013, pending approval to use $950 million in Proposition 1A bonds to match federal funding. (Legal issues have yet to be cleared as of November, 2013.) Step 1 is the building of the Initial Operating Section (IOS).



construction schedule for CA HSR

The first construction zone has been considered the "spine" of the HSR and is located in the Central Valley, and it is to be a 130-mile stretch that runs from north of Fresno to Bakersfield (as highlighted by the dark green line on the map). According to the plan, this section will connect the San Joaquin, ACE, Sacramento Regional Transit, the Capitol Corridor (and potentially Caltrain) passenger lines that already exist. They will be able to use the new HSR tracks without additional costs or upgrades. The first step will not include actual High-Speed train operation, but it will improve the existing network known as the Northern California Unified Service (NCUS) containing the aforementioned lines. This first step is also visualized in the construction schedule to the left. The previous paragraph refers to what they are calling first construction (in the light green) and is proposed to be finished by 2017.

Proposed California High-Speed Rail route from Revised 2012 Business Plan

The second step of the this phase is to close the gap between Bakersfield and Palmdale, creating greater reach for the NCUS. This section is projected to cost $4 billion and will need to traverse through the Tehachapi Mountains. This second step would complete the IOS with a projected finish date of approximately 2022.

STEP 2 - Initial High-speed Rail Operations

The second step is to begin high-speed rail operations. All necessary features will be put in place such as signals, rail cars, revenue services, safety, and electrification of the line. The business plan actually places the completion of the rail line through the Tehachapi Mountains in Step 1 and Step 2. According to the Plan, the IOS is only defined as extending from Merced to San Fernando Valley. High-Speed Train operations will only begin once the complete IOS is built and operable. Before that, some of the finished line will be used by Amtrak and other passenger lines.


Section	Length (approx)	Endpoints	Service Description	Service Start	Cumulative Cost (YOE$, billions)
Initial Operating Section	300 miles	Merced to San Fernando Valley	• One-seat ride from Merced to San Fernando Valley • Closes north-south intercity rail gap, connecting Bakersfield and Palmdale and then into Los Angeles Basin • Begins with construction of up to 130 miles of HSR track and structures in Central Valley • Private sector operator • Ridership and revenues sufficient to attract private capital for expansion • Connects with enhanced regional/local rail for blended operations, with common ticketing	2022	$43
Bay to Basin	410 miles	San Jose and Merced to San Fernando Valley	• One-seat ride between San Francisco and San Fernando Valley[1] • Shared use of electrified/upgraded Caltrain corridor between San Jose and San Francisco Transbay Transit Center • First HSR service to connect the San Francisco Bay Area with the Los Angeles Basin	2026	$51
Phase 1 Blended	520 miles	San Francisco to Los Angeles/ Anaheim	• One-seat ride between San Francisco and Los Angeles[1] • Dedicated HSR infrastructure between San Jose and Los Angeles Union Station • Shared use of electrified/upgraded Caltrain corridor between San Jose and San Francisco Transbay Transit Center • Upgraded Metrolink corridor from LA to Anaheim	2029	$68

[1] One-seat ride means that passengers do not need to switch trains, even if the train operates over two systems (e.g., moving north on dedicated high-speed rail infrastructure and then moving onto Caltrain tracks at San Jose, assuming electrification of
Timeframe

STEP 3 - The Bay to Basin System

At this stage, the dedicated HSR system will be built northwest to San Jose, providing passengers with the ability to ride one-seat from San Fernando Station to San Francisco. However, this plan relies on assumptions that Caltrain will electrify their lines by 2020 as proposed. It also should be noted that this one-seat trip will not be on dedicated HSR tracks the entire way. From San Francisco to San Jose, passengers would rely

on "blended" infrastructure, which means that the high-speed train would actually be traveling on electrified Caltrain tracks. The trip from San Fernando Valley to Los Angelos would be via Metrolink. The only dedicated HSR track would be from San Jose to San Fernando Valley.

STEP 4 - The Phase 1 System

There are two scenarios considered in Step 4; blended and Full Build. The blended scenario would involve building dedicated high-speed tracks from San Fernando Valley to Los Angeles, leaving San Jose to San Francisco tracks blended with electrified Caltrain. The Full Build scenario would involve building dedicated HSR from San Jose to San Francisco, and Los Angeles to Anaheim.

STEP 5 - The Phase 2 System

The final phase consists of constructed dedicated HSR to San Diego and Sacramento. The plan states that even prior to this phase, those in the area will benefit from earlier investments through the blended approach. This will complete the 800-mile high-speed rail system in California. Timelines for Phase 2 have not been given at this time.

LEGISLATION

INTERCITY HSR COMMISSION

Senate Concurrent Resolution bill number SCR 6, Kopp. Transportation: intercity high-speed rail network[16] was first introduced in the Senate on January 12, 1993, and was filed with the Secretary of State later that year on July 20, 1993. The measure established the Intercity High-Speed Rail Commission which was to "prepare a 20-year high-speed intercity ground transportation plan, as specified, for implementation beginning in the year 2000. In SCR (Senate Concurrent Resolution) No. 6 Relative to transportation, the reasons stated justifying the development (and ultimate deployment) of HSR in California included: (1) California has spent decades building an expansive network of freeways and airports, but they do not meet the current demands of the population and the population is expected to grow; (2) Expanding the current highway and/or airport network would be expensive, environmentally unfriendly, and prohibitive; (3) Intercity rail is efficient, practical, and less polluting and could fill gap between future demand and current capacity; (4) HSR systems in Europe and Japan compete effectively for passengers on trips between 200 to 500 miles apart; (5) Building a intercity HSR will stimulate the economy by generating jobs and setting up future generations with HSR. Within the bill, the duties and objectives of the Intercity High-Speed Rail Committee are outlined. The Committee was to develop a plan that had the San Francisco to Los Angeles line be its first priority, focus only on intermediate intercity travel, leaving local and commute trips to other urban transit forms. SCR 6 proposed that construction for the "State-of-the-art, high-speed ground transportation" connecting the two main cities should be started as soon as 2000, so that services could begin in 2020.

CALIFORNIA HSR AUTHORITY

Senate Bill number SB 1420 Chapter 796 Transportation: High-Speed Rail Act (HSR Act) was introduced by Senators Kopp and Costa on January 23, 1996, and was officially filed with the Secretary of State on September 24, 1996[17]. The HSR Act established the California High-Speed Rail Authority (CaHSRA or also referred to simply as the Authority), which is the driving force that has been behind all of the planning and preparation

activities regarding the California High-Speed Rail. The committee was established as a committee of nine government appointed members to develop plans that coincided with the previous work that the Intercity High-Speed Rail Commission had already put forth since 1993. The bill gave the Authority the right to conduct all engineering and project development including, but not limited too, accepting public or private funds, allocating resources, and proposing routes and terminals. In a nut-shell the Authority was established as the general manager of all HSR project details, and was established to be ready to contract for the design, construction and operation of the HSR pursuant of either voter or legislative approval.

PROPOSITION 1A[18]

Proposition 1A was a bill passed during the 2008 primary election in California with approximately 6.7 million votes in favor, making it victorious by 52.6%. The bill approved the issuing of "$9.95 billion in general obligation bonds, to plan and to partially fund the construction of a high-speed train system in California..." Proposition 1A was a big victory for the proponents of the California High-Speed Rail.

California votes by county on Proposition 1A

The $9.95 billion in bonds was estimated to cost $20 billion in the long run; $9.95 in principal payments and $9.95 billion in interest over the next 30 years. California already had $100 billion in bond debt and had one of the worst bond ratings in the nation. Proposition 1A stated that the entire HSR project would cost around $45 billion. It stated all the proposed routes as well.

One thing that is interesting about the voting spread is that the majority of the counties that voted yes are counties in which the HSR is proposed to travel through, providing the most convenient service too.

Proponents

Those in favor of the bill argued that California's transportation system was broken, and that a HSR would provide oil independence and greenhouse gas reduction. They claimed that the HSR would not mean higher taxes, and that it would be cheaper than building new roads or airports. Proposition 1A would "bring Californians a safe, convenient, affordable, and reliable alternative to soaring gasoline prices, freeway congestion, rising airfares, plummeting airline service, and fewer flights available." They claimed that the HSR would carry 70 million passenger trips a year and that this would clear up the congested roads. They cheered that this would be the first HSR in the country, and that they are common in other parts of the world. The fact that at least 10 years of planning and preparation had gone into the HSR already was used to reassure voters. The HSR would save money for Californians, they claimed, comparing the expected cost and travel time of a one-way ride versus a 20 mpg car traveling the same distance. A new HSR would also clear up airport congestion, because travelers would have an alternative choice that would be easy to make, since air travel is time consuming. They also argued that the all electric HSR would save about 12 billion pounds of CO_2 and greenhouse gasses, not to mention HSR requires 1/5 the energy of auto and 1/3 that of airplanes. Finally, the project will "create 160,000 construction-related jobs and 450,000 permanent jobs."

The proponents were adamant that Proposition 1A would not lead to tax increases.

Opponents

Those against Proposition 1A tried to direct attention to the costs of the HSR and the concurrent bond act. They stressed that it would take approximately 30 years for the state to pay back the principal and interest on $9.95 billion in bonds, which equates to payments of approximately $647 million a year. They feared Californians might not be able to grasp the implications of this. They warned that the bonds would likely move California from 4th highest taxed state in America to highest taxed state, bumping out New York. They warned that the train may not ever get built, yet the bonds would be repaid regardless. They argued that investments in expanding existing transit systems would be wiser. They stated that California was already in $100 billion bond debt, and that there bond rating was among the worst in the country. To put the $20 billion in perspective and gave concrete examples of what that could do, like upgrading the California's water system to provide clean and reliable water for years to come.

California Law AB 3034 established a Peer Review Group whose duty is to evaluate the California High Speed Rail Authority's funding plans and prepare its independent judgment as to the feasibility and the reasonableness of the Authority's plans, appropriateness of assumptions, analyses and estimates, and any observations or evaluations the Group deems necessary. The group found that the Authority's business model was incomplete, and said it was simply an "illustrative" concept rather than a concrete plan. It considered the lack of any long term funding a "fundamental flaw", and that the Authority was not up to the task of managing a project of such size.

The former chairman of the CHSRA, Quentin Kopp, is now a vocal critic of the project, due to its "blended approach." In September of 2013, Governor Brown signed a bill into law that makes it virtually impossible for the Authority to build track through communities like Palo Alto and Menlo Park in the Tony Peninsula. Instead, the HSR will operate on the same track as local commuter trains. Kopp says the law fundamentally alters the original plan that voters approved, Proposition 1A. Kopp asserts the new "blended approach" will slow train speeds and decrease the number of trains that can run on the HSR system. He states "the project has been mangled - it's been completely mangled," and that he system won't generate enough ridership and gross revenue to pay the trains' operating costs[19]..

AMERICAN RECOVERY AND REINVESTMENT ACT

The American Recovery and Reinvestment Act is often referred to as the Stimulus or The Recovery Act. It was an economic stimulus package priced initially around $787 billion that later ended around $831 billion, passed by the United States Congress in February 2009 and signed into law by President Barack Obama that same month. The main objective of The Recovery Act was to stimulate the economy by creating immediate jobs through infrastructure, health, education, and energy spending, and tax incentives and social welfare improvements.

High Speed Rail 07-09-2009

Of the $48.1 billion allocated for transportation infrastructure improvements, $8 billion was dedicated for intercity passenger rail projects, with a priority for high-speed rail. In October of 2009, California Governor Arnold Schwarzenegger released the application for $4.7 billion of the $8 billion rail portion, and in January, 2010, the White House granted California $2.35 billion. In October of 2010, the Federal government awarded the Authority $900 million for passenger rail improvements, bringing total federal government support up to about $4.3 billion. Later in 2010, the Department of Transportation (DOT) redistributed $624 million in federal funding declined by states such as Ohio and Wisconsin. Mid 2011, the DOT redistributed more declined money to the authority, this time about $300 million.

SURROUNDING ISSUES

ARRA in Rhode Island

Proposition 1A stated that the 12 prior years of research and construction planning coordinated by the California High-Speed Rail Authority would allow them to break ground on the project as early as 2011 with funding help from the bond act. Fast forward to today (November, 2013) with no guaranteed start date in sight, amidst unsettling economic delays, legal troubles, rising projected costs, and an intriguing alternative proposal suggested by billionaire entrepreneur-slash-engineer-slash-businessman, Elon Musk, data suggests that voters may no longer feel the same way about the proposed HSR as they did in 2008[20]. What was supposed to be a $48 billion dollar transportation project has actually risen into an estimated $68 billion dollar project, a number that does not actually reflect the total cost of the planned system. The estimated $68 billion dollars that is often cited is only for Phase I of the project. Phase II, which would complete the 800-mile system has no estimated associated costs and no timeline. Yet still, according to the California High-Speed Rail Authority (CHSRA) and their 2012 Business Plan, the project is expected to be completed fully by 2029, with first phase (the Initial Operating Section, from Merced to San Fernando Valley) services expected to begin in 2022.

According to the CaHSRA, the average ticket far for a trip from San Francisco to Los Angelos will be about $81 in 2010 dollars making it only $6 cheaper than the estimated costs stated in Propostion 1A to drive the same route. Proposition 1A, which gave CA government the ability to sell $9.95 billion in bonds by convincing the CA people that a HSR would be beneficial used the argument that it would cost roughly $50 (2008 dollars) to make that trip.

In October, 2013 Gov. Jerry Brown vetoed bill AB 374, which was written by Republican Assemblyman Don Wagner as an act to amend current eminent domain law Section 1263.510. The goal of the amendment is to give victims of eminent domain a greater chance for compensation by allowing them to “adduce sufficient evidence” in front of a jury, rather than having their compensation being decided purely by a judge (Wagner, 2013). The bill, which did not receive a single NO vote from either house, but was vetoed by the Governor, will likely result in cost-savings in the overall HSR project (though an almost trivial amount compared to the overall cost), however, at removed business owners expenses.

In October, 2013, a subcontractor hired to investigate environmental impacts of the HSR in California during the planning stages of construction has sued the California High Speed Rail Authority and STV, the primary contractor, for $4.7 million due to complications regarding their removal from the project, and $2 million in outstanding payments (Reynolds, 2013).

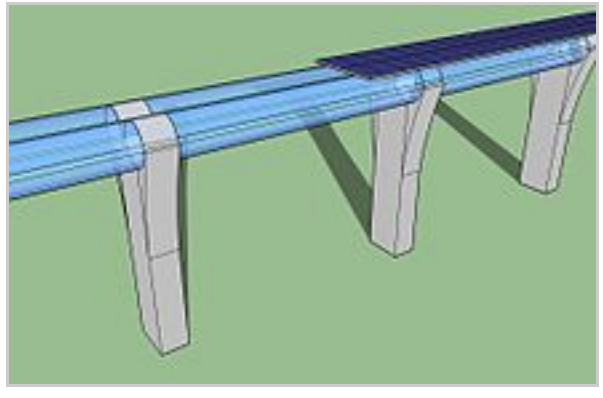
Construction on the CA HSR was to begin in 2012, according to state officials, with a projected completion date set to 2029. However, after continuous setbacks, the start date was re-adjusted for July 2013, and now, with 2 months left in 2013, evidence suggests that construction won’t likely begin until 2014 (Vartabedian, 2013). The fact that the CA HSR is missing delayed start dates indicates that the project was not as “shovel-ready” as it was played out to be in 2010 when it was qualified and awarded $2.25 billion in Obama Administration stimulus funding as a part of the American Recovery and Reinvestment Act, even though the California High Speed Rail Authority spent $60 million over 12 years prior to 2008 in “pre-construction activities,” according to Proposition 1A.

Adding further complications, the current federal grant agreements require that the California High-Speed Rail Authority spend and match the current federal grant funding on the high speed project by 2017, otherwise they must forfeit the funds. That translates into the authority spending $5 billion of the projected $6 billion that is projected for the first phase through the Central Valley. This, according to an article in the LA Times, would mean that the authority would need to spend “roughly $3.75 million per day, including weekends and holidays – one of the fastest rates of spending on a major construction project in U.S. history (Vartabedian, 2013)” if they started in January of 2014.

HYPERLOOP

WHAT'S THE HYPE?

In August 2013, Elon Musk, co-founder of PayPal and Tesla Motors, founder of SpaceX, and chairman of SolarCity, presented an alternative solution to HSR that could be safer, faster, and cheaper, while at the same time fulfilling every single objective stated in Proposition 1A that was used to defend the HSR in the first place. His plan, which he has dubbed ‘Hyperloop',[2] is for a system of low pressure, elevated tubes in which capsules or pods (used interchangeably) carrying travelers, can travel through at up to 4,000 mph. Think highly sophisticated, enlarged versions of the pneumatic tubes used at many banks to send things back-and-forth between clients in vehicles and the tellers inside. What is quite possibly Hyperloop’s greatest asset is in how it was presented, when it was presented, and by whom. His plans have stirred much debate. Questions about whether or not Hyperloop is technically feasible is one thing, but on top of that, it has drawn much more attention to the California HSR project, and made many more people aware of its current state and its actual implications.



Hyperloop

OVERVIEW

Transporting goods and people through evacuated tubes has been around since the Victorian era. The system works by pushing capsules through a tube by removing the air in the tube. On a small scale, pneumatic tubes are used to transfer parcels or messages inside office buildings. Since most of these small-scale systems were used to transport paper notes (in essence, data), the rise of the fax machine, and later the internet, saw their popularity fall by the wayside, however they are still used extensively at drive-up banking centers. Many late 19th-century authors imagined a not-too-distant future where pneumatic public transport is ubiquitous. Obviously, this future has not been realized yet.

The biggest problem as a tube is scaled up is managing the vacuum. It takes an immense amount of power to evacuate the tube completely, and the longer the tube becomes, the more difficult it becomes (As length doubles, volume increases by a factor of 4), and the likelihood of failures doubles. A solution to this is to only partially evacuate the tube (a "soft vacuum" instead of a "hard vacuum"). This lowers the energy input, but even partially evacuated tubes create an air pressure problem

Elon Musk (Artist's Interpretation)

at high speeds. Furthermore, the propulsion of most parcel-delivering pneumatic tubes comes from creating a pressure differential so that a column of air pushes the capsule along. This form of propulsion faces the same limitations as evacuating the tube, as they are intrinsically linked. Furthermore, the friction created by the 350 mile long column of air in the tube would be impossible to overcome.


(Actual) Elon Musk

The solution proposed by Hyperloop is to install a compressor on the capsule that will move the air that piles up in front of the capsule behind it. The propulsion for the Hyperloop would then be provided by linear accelerator motors (such as the ones used in high-speed launched roller coasters) that would accelerate and brake the pods. The pods themselves would ride on cushions of air that would be directed down to skis from the compressor on the front of the pod, thus using the air that is moved through the pod for work, rather than just getting it out of the way. Musk claims that the Hyperloop, using these methods, can reach speeds of just over 700 mph.[2] Musk also claims that the Hyperloop is a more economical option for linking cities that are 900 miles apart or less than supersonic air travel (which he believes will be widespread in the near future).[2] Musk released a 60+ page technical document in August, 2013 that outlined the vision for the Hyperloop. He begins with an executive summary overview that describes the project then the remainder of the document is a more technical analysis.

TECHNOLOGY

The main technology behind the Hyperloop is in the pod or capsule, and in the tube itself. Musk claims that the technology needed currently exists and is in use today, though at much different scales.

Capsule

Many of the major design elements are related to the capsules. These capsules are the actual vehicle that people would theoretically travel in. The report describes two different types of capsule; a passenger only, and a passenger+vehicle that can carry 3 cars as well as passengers.

The capsule consists of (from front to back) an inlet, fan, motor, firewall, seating compartment, and batteries, with the suspension underneath. The interior will feature seats designed to ease passenger's discomfort during acceleration and deceleration and will have their own entertainment systems.

The compressor on the front of the capsule will be driven by an electric motor, and will take in the air that is compressed in front of the capsule. the majority of that air is bypassed, and the remaining is cooled using tanks of water and diverted down to form a cushion on which the capsule rides. This air cushion is similar in principle to how an air hockey table works, only the air in this analogy is coming from the puck rather than the table surface. Each "ski" that the capsule is riding on will have an independent mechanical suspension so that any inconsistencies in the tube surface are not transferred to the riders. Additionally, the capsules will have deployable wheels similar to the landing gear of airplanes for traveling at low speeds and for added safety.

Propulsion for the capsule will be provided by linear accelerator motors. These motors are used most notably in roller coasters such as Top Thrill Dragster at Cedar Point, Ohio. The moving element of the motor will be on the capsule. These motors will also act as the primary braking system.

Tube

The Hyperloop capsules will run in an elevated tube that will be a complete loop between LA and San Francisco. The tube would be pre-fabricated and made out of steel reinforced with stringers. The tube would be elevated with pillar supports roughly every 100 feet, and the two directions would be mounted on the same pillar. The pillars will keep the tube from moving up and down, but will allow longitudinal slip to account for thermal expansion and contraction. The static portion of the linear motors would be mounted to certain sections of the tube to provide acceleration and breaking, as well as guiding the banking of the capsule around curves, however the majority of the trip would be un motorized. The tube would be partially evacuated to a pressure 1/6 that of the air pressure on the surface of Mars by continually running commercial vacuum pumps that would be placed along the route. Stations at either end would consist of airlocks where the pressure around the capsule would be equalized either to the pressure in the tube or to the ambient pressure, depending on if it is the origin or destination station.

Safety

Musk claims that the system would be safer than trains, planes, or cars. The capsules would have direct radio links to the stations to request help in the case of an emergency. Due to the high speed of travel, if there were a medical emergency onboard a capsule, the best course of acton would be to use a supplied first aid kit and to continue to the destination, as it would be quicker than decelerating the pod and getting an emergency crew to the stopped capsule along the route.

In the case of a power outage, all of the motors would have enough reserve power to accelerate and decelerate all current capsules in the system normally. Once all of those capsules reached their destination, further capsules would be delayed until power was restored. Furthermore, all capsules would be fitted with manual emergency brakes. In the case of depressurization, oxygen masks similar to those on commercial airliners would drop down for the passengers. In the case of any compromise in the tube or one of the capsules, all of the capsules would emergency brake, and the electric motor would drive the deployable wheels which would then take the capsules to their destinations.

COSTS

The report outlines the estimated costs in the following table. The total estimated cost is $7.5 Billion

CRITICISMS

Almost as soon as Musk published the technical report, criticisms began surfacing all over the internet. Most focus on the feasibility and the cost. The assumptions the report make regarding the cost of the system relative to conventional (or high-speed) rail have come into question. the report states to cut costs the Hyperloop would be built in the median of I-5 for the majority of its route, thus eliminating its need to procure land, and the report

cites the system's elevated nature to be an asset. Many critics do not belive this to be the case. Mass Transportation writer Alon Levy said that "In reality, an all-elevated system (which is what Musk proposes with the Hyperloop) is a bug rather than a feature. Central Valley land is cheap; pylons are expensive, as can be readily seen by the costs of elevated highways and trains all over the world."[21] Michael Anderson, a professor of agricultural and resource economics at UC Berkeley, predicted "You're talking $100 billion to build what they're proposing."[22]

The report suggest a ticket price of $20 would cover capital costs based on an estimated ridership of 7.4 million passengers a year each way over 20 years.[2]Dan Sperling, director of the Institute of Transportation Studies at UC Davis, told Al Jazeera America that "there's no way the economics on that would ever work out."[22]

However, not all of the press has been poor. Popular Science released a very interesting interactive infographic showing estimated trip times on a continent-spanning Hyperloop network.[23]

HYPERLOOP TRANSPORTATION TECHNOLOGIES INC

In the beginning of November, a new company, Hyperloop Transportation Technologies Inc. was created. The company is seeking funds and team members on JumpStartFund, a crowdsourcing website designed to help aspiring companies.[24] The company will be headed by Dr. Marco Villa, former director of mission operations for SpaceX and Dr. Patricia Galloway, first female president of American Society of Civil Engineers and was a former member of the US National Science Board. The purpose of the company is to design and test the Hyperloop, and its ultimate goal is to implement the system in California.[25]

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